PB-215 949

WATER SUPPLY AND WATER QUALITY CONTROL STUDY, OSAGE RIVER BASIN, KANSAS AND MISSOURI: STUDY OF NEEDS AND VALUE OF STORAGE FOR MUNICIPAL AND INDUSTRIAL WATER SUPPLY AND WATER QUALITY CONTROL

Public Health Service
Kansas City, Missouri

August 1965

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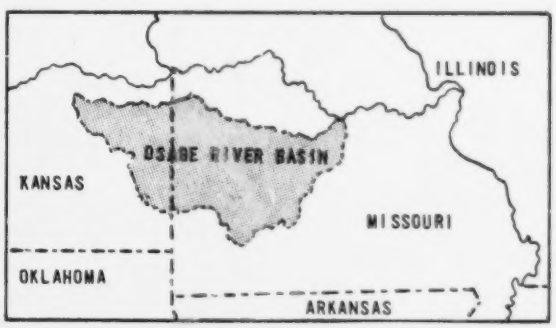
WATER SUPPLY AND WATER QUALITY CONTROL STUDY OSAGE RIVER BASIN KANSAS AND MISSOURI

Study of the Needs and Value of Storage for Municipal and Industrial Water Supply and Water Quality Control



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August 1965

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Public Health Service
General publications

Os 1 Water supply and water quality control study, Osage River basin, Kans. and Mo., study of needs and value of storage for municipal and industrial water supply and water quality control [with bibliography]. Kansas City, Mo., Aug. 1965. [Prepared for Army Engineer District, Kansas City, Mo., Region 6,] Environmental Protection Agency

(No LC number)

WATER SUPPLY AND

WATER QUALITY CONTROL STUDY

OSAGE RIVER BASIN

KANSAS AND MISSOURI

ABSTRACT

A survey has been made which discloses immediate and future needs for municipal and industrial water supplies and storage for streamflow regulation for the purpose of water quality control. Future needs are based on results of economic and demographic studies projecting population and industrial growth.

Prepared for

DEPARTMENT OF THE ARMY

U. S. Army Engineer District

Kansas City, Missouri

August 1965

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I. INTRODUCTION

Request and Authority

In letters dated November 16, 1961 and September 18, 1964, the Kansas City District of the Corps of Engineers requested that the Public Health Service determine the present and prospective needs for municipal and industrial uses and for water quality control in the Osage River Basin in Kansas and Missouri.

This study has been made in accordance with the Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare, relative to the Water Supply Act, as amended (43 USC 390b) and the Federal Water Pollution Control Act, as amended (33 USC 466 et seq).

Purpose and Scope

The purpose of this study is to determine the need for and value of storage for municipal and industrial water supply and for quality control in the Osage River Basin. The Osage River Basin, a 15,300 square mile area, including all or portions of 39 counties, is located in east-central Kansas and west-central Missouri. The study covers a 100-year period, 1960 to 2060, as requested by the Corps of Engineers.

Acknowledgments

The cooperation and assistance of many persons and agencies are gratefully acknowledged. Special appreciation is expressed to the following:

1. Corps of Engineers, Kansas City District, Kansas City, Missouri
2. Missouri Water Pollution Board, Jefferson City, Missouri
3. Missouri Division of Health, Jefferson City, Missouri
4. Missouri Water Resources Board, Jefferson City, Missouri
5. Missouri State Geological Survey and Water Resources, Rolla, Mo.
6. Missouri Industrial Development Commission, Jefferson City, Mo.
7. City Officials, Springfield, Missouri
8. Chamber of Commerce, Springfield, Missouri
9. Kansas State Geological Survey, Department of Oil and Gas, Lawrence, Kansas
10. Kansas State Department of Health, Topeka, Kansas
11. Kansas Water Resources Board, Topeka, Kansas
12. U. S. Geological Survey, Surface Water Branch, Topeka, Kansas and Rolla, Missouri
13. U. S. Geological Survey, Quality of Water Branch, Topeka, Kansas
14. U. S. Geological Survey, Ground Water Branch, Lawrence, Kansas

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The Corps of Engineers has proposed construction of a system of nine reservoirs on the Osage (Marais des Cygnes) River and its tributaries. The primary purposes of these reservoirs are flood control, navigation, power generation, municipal and industrial water supply and streamflow regulation for quality control.

2. The study area is the 15,300 square mile Osage River Basin located in east-central Kansas and west-central Missouri.

3. Population of the economic study area was 434,776 in 1960 of which 183,661 were urban and 251,115 were rural.

4. The principal communities in the basin and their 1960 populations are: Fort Scott, Kansas - 9,410, Ottawa, Kansas - 10,673, Clinton, Missouri - 6,925, Lebanon, Missouri - 8,220 and Nevada, Missouri - 8,416. Springfield, Missouri - 95,864 is contiguous to the basin.

5. Average daily 1963 water use from municipal water supplies in the basin amounts to 21.5 million gallons per day (mgd) to supply a population of 232,839 or an average per capita use of approximately 92 gallons per capita per day (gpcd).

6. The surface water is suitable for most municipal and industrial water uses after conventional treatment. A belt of fresh to brackish ground water 10 to 20 miles wide extends across the basin on a line from Nevada to Warrensburg, Missouri. To the west of this area adequate quantities of relatively good quality ground water are not available. To the east of this area generally adequate supplies of ground water are

available that are suitable for most municipal and industrial water uses after conventional treatment.

7. The raw wastes, in population equivalents (P.E.) are 13,300 P.E. at Fort Scott, 14,000 P.E. at Ottawa, 6,200 P.E. at Clinton, 7,800 P.E. at Nevada, 10,700 P.E. at Lebanon, 4,800 P.E. at Belton, 8,200 P.E. at Eldorado Springs, and 23,000 P.E. from the part of Springfield that discharges its wastes to the Osage River Basin. The equivalent of secondary waste treatment is provided by most of the systems in the study area resulting in an average Biochemical Oxygen Demand (BOD) removal of approximately 86 percent.

8. The study area is divided into 13 subareas, based on drainage systems, for determination of water needs. See map of study area at back of report.

Conclusions

1. The total population of the study area is estimated to grow from 434,776 persons in 1960 to 710,000 persons by 2010 and to 1,200,000 persons by 2060. The urban population is expected to grow from 183,661 persons in 1960 to 500,000 by 2010, to 1,000,000 persons by 2060.

2. Based on economic projections and projected per capita water use, the municipal and industrial water demands in the study area will increase to 88 mgd by 2010 and 225 mgd by 2060.

3. Table II-1 lists the yields from storage needed in 2060 to meet the municipal and industrial requirements in the various subareas, the year storage is first needed, and the annual value of this storage based on the most feasible alternative.

Table II-1

Summary of Yields From Storage Needs in 2060
To Meet Municipal and Industrial Water Requirements,
Year of First Need, and Annual Value of Storage
Osage River Basin

Subarea and Area of Major Demand	Year of First Need	Yield from Storage (mgd)	Annual Value of Storage($)
4 (Ottawa Area)	1980	6	50,000
5 (Garnett Area)	2010	1	7,100
6 (Paola Area)	1960	4	121,000
7 (Butler Area)	1960	2	18,300
8 (Fort Scott and Nevada Areas)	2010	5	18,700
12 (Harrisonville)	1990	1	17,500
12 (Freeman)	1980	20	161,600
1,2,3,9,10,11 and 13	--	0	0

4. Table No. II-2 lists the annual draft on storage* needed in 2060 for streamflow regulation for quality control in the various subareas, the year regulation is first needed, and the annual value of benefits based on the most feasible alternative.

Table No. II-2

Summary of Net Regulation Requirements In
Acre-Feet Per Year in 2060, Year of First Need,
and Annual Value of Benefits
Osage River Basin

Subarea and Area of Major Waste Loading	Year of First Need	Draft on Storage Acre Feet/Year	Annual Value of Benefits ($)
4 (Ottawa & Osawatomie Area)	1960	12,200	$ 82,100
5 (Garnett Area)	2040	600	500
6 (Paola Area)	1960	9,100	95,200
7 (Butler Area)	1960	6,600	56,000

*Annual draft on storage is the sum of the incremental excesses of needed releases over inflows during a climatic year.

(continued)

Table No. II-2 (continued)

Summary of Net Regulation Requirements In Acre-Feet Per Year in 2060, Year of First Need and Annual Value of Benefits Osage River Basin

Subarea and Area of Major Waste Loading	Year of First Need	Draft on Storage Acre Feet/Year	Annual Value of Benefits ($)
8 (Fort Scott & Nevada Areas)	1960	11,200	$ 76,000
9 (Eldorado Springs Area)	1960	2,800	63,000
12 (Harrisonville Area)	1960	1,900	46,000

These benefits may be credited to storage for water quality control only if assurance is given that adequate waste treatment will be provided.

5. Maintenance of satisfactory water quality through streamflow regulation in the Osage River Basin will benefit a wide spectrum of water uses in the study area. By 2060, a million people will live in the area and over 3,000,000 additional people will be living adjacent to the basin in the Kansas City metropolitan area. These people will benefit by the improvement of water quality in approximately 700 river miles of stream in the basin. New municipal and industrial raw water supplies of satisfactory quality will be available. Water treatment costs will be decreased by having a raw water source of a more uniform quality. Municipal growth will not be jeopardized by a shortage of water.

Recreational opportunities, including fishing, swimming and boating will be increased. The Creel census data collected by the Missouri Conservation Commission indicate a predominance of rough fish. The Fish

III. PROJECT DESCRIPTION

Location

The main stem of the Osage (Marais des Cygnes) River rises in east-central Kansas not far from Osage City, and flows in a generally easterly direction for about 500 miles, emptying into the Missouri River 15 miles downstream from Jefferson City, Missouri and 130 miles above the confluence of the Missouri River with the Mississippi. The river system is south of the Kansas River Basin in Kansas and south of the Missouri River in Missouri. It drains 15,300 square miles. Of that area, 11,000 square miles are in Missouri and 4,300 in Kansas. See map at back of report.

The proposed plan of improvement for the Osage (Marais des Cygnes) River Basin includes nine reservoirs as shown below:

Name	Location	Status
Pomona	Hundred & Ten Mile Creek below Dragoon Creek	Complete
Pomme de Terre	Pomme de Terre River below Lindley Creek	Complete
Kaysinger Bluff	Osage River above Warsaw	Construction
Stockton	Sac River near Stockton	Construction
Hackleman Corner	Horse Creek above Sac River	Deferred
Fort Scott	Marmaton River near Fort Scott	Advance Planning
Garnett	Pottawatomie Creek near Garnett	Authorized
Melvern	Marais des Cygnes River above Sail Creek	Advance Planning
Hillsdale	Big Bull Creek above Paola	Authorized

Additional information on the capacities and locations of the pro-

posed reservoirs is given on Exhibit No. 1 in the Appendix.

Streamflow

Flows in the lower Osage River near Bagnell, Missouri (drainage area, 14,000 square miles) have ranged from a maximum of 220,000 cfs to a minimum of 220 cfs at that same station and averaged 9,581 cfs over an 83 year record. At least 15 stations on minor tributaries or headwaters of the Osage River have recorded periods of no flow occurring usually during the summer months.

Historical streamflows are shown on Exhibit No. 3.

Water Quality

There are no published stream quality analyses for the entire Osage (Marais des Cygnes) River Basin but available unpublished data from the U. S. Geological Survey and the States of Missouri and Kansas indicate the following ranges in mineral concentrations in the Osage River Basin:

Stream and Location	Ranges of Observed Mineral Concentrations (Minimum to Maximum) mg/l			
	Hardness (as $CaCO_3$)	Sulfate (SO_4)	Chlorides (Cl)	Dissolved Solids
Marais des Cygnes 22/ near Worland, Mo.	119-310	20-63	7.0-20	166-400
Osage River 22/ at Osceola, Mo.	138-304	22-157	5.0-22	176-382
Sac River 22/ near Stockton, Mo.	148-221	11-16	4.0-6.0	160-238
South Grand River 22/ near Brownington, Mo.	97-310	29-173	3.6-30	132-424

(continued)

(continued)

Stream and Location	Ranges of Observed Mineral Concentrations (Minimum to Maximum) mg/l			
	Hardness (as $CaCO_3$)	Sulfate (SO_4)	Chlorides (Cl)	Dissolved Solids
Pomme de Terre River 22/ near Bolivar, Mo.	168-230	8.8-14	4.2-10	173-239
Marais des Cygnes 21/ at Ottawa, Kansas	74-404	9.5-105	2-28	126-464

Additional quality data are presented in Exhibit No. 5.

Below some of the major municipalities in the basin, due to inadequate treatment and/or periods of low flow, there are at present, times when the low point of the oxygen-sag curves fall below recommended concentrations. There have been fish kills reported and the lower oxygen concentrations also adversely affect recreational uses of these reaches.

Pertinent Data

The proposed reservoir system in the Osage River Basin will control a drainage area of 11,500 square miles which is approximately 75 percent of the Osage River Basin.

Total storage in the nine proposed reservoirs is shown below:

Purpose	Space in Acre Feet
Flood Control	6,044,800
Conservation	2,437,250
Sediment	366,450
Total	8,848,500

Storage capacities of each reservoir are shown in Exhibit No. 1.

Watershed Work Plan

A watershed Work Plan for the Frog Creek Watershed in the state of Kansas has been developed by the Soil Conservation Service. The watershed

is located in the north-central part of Coffey County and the south-central part of Osage County, Kansas. The watershed contains 35.15 square miles or 22,496 acres of which 13,319 acres are in Coffey County and 9,177 acres are in Osage County. Frog Creek is a branch of Long Creek, a tributary of the Marais des Cygnes River.

The structural measures included in the watershed work plan consist of eight floodwater retarding structures having an aggregate storage capacity of 4,661 acre-feet.

IV. DESCRIPTION OF STUDY AREA

Location and Boundaries

The Marais des Cygnes River, known in Missouri as the Osage, rises near Osage City, Kansas, and flows easterly and southeasterly 190 miles to the Kansas-Missouri State line, thence east in Missouri 306 miles to empty into the Missouri River east of Jefferson City. The Kansas portion of the basin is south of the Kansas River Basin and the Missouri portion is south of the Missouri River. Of the 15,300 square miles in the Osage River Basin, 11,000 square miles are in Missouri. See map of study area at back of report.

The study area, as requested by the Corps of Engineers, is the Osage River Basin covering all or portions of the following counties: In Kansas - Crawford, Allen, Lyon, Bourbon, Linn, Anderson, Coffey, Osage, Wabaunsee, Douglas, Franklin, Johnson and Miami; and in Missouri - Vernon, Barton, Cedar, Dade, Lawrence, Polk, Green, Webster, Dallas, LaClede, Pulaski, Christian, Maries, Osage, Cole, Miller, Morgan, Camden, Benton, Hickory, Johnson, Jackson, Cass, Henry, St. Clair, and Bates.

Geography and Topography

Lands in the Osage (Marais des Cygnes) River Basin rise from an elevation of 520 feet above mean sea level at the mouth to approximately 1,450 feet at the headwaters. The eastern portion of the basin, a typical rough and hilly Ozarks area, is formed of a series of limestone and dolomites ranging in age from Cambrian to Mississippian. West of Osceola, Missouri, the basin is characterized by gently rolling uplands of the Osage plains. This part of the basin is underlain by a thick

series of shales, sandstones, and limestones of Pennsylvania Age.

Climate

The Osage (Marais des Cygnes) River Basin climate is characterized by moderately cold winters and hot summers. July is normally the warmest month with an average daily maximum of 90° and an average daily minimum of 70°. Within this area maximum temperatures have reached 120° F. and the minimum temperatures have dropped as low as 28° F. below zero. The average frost-free growing season is approximately 185 days.

Principal Communities

The principal communities in the study area and their 1960 populations are:

Municipality	1960 Population	State
Fort Scott	9,410	Kansas
Belton	4,897	Missouri
Ottawa	10,673	Kansas
Lebanon	8,220	Missouri
Clinton	6,925	Missouri
Nevada	8,416	Missouri
Springfield (Edge of Basin)	95,864	Missouri

Subareas

The basin was divided into 13 subareas to estimate the future storage needs for both municipal and industrial water supplies and streamflow regulation for quality control. These areas are shown on the map of the study area and Table IV-1 lists these subareas along with some descriptive remarks.

Table IV-1

Description of Subareas
Osage River Basin

Subarea	Description	Major Streams	Reservoirs
1	Total drainage area of Dragoon Creek and Hundred Ten Mile Creek	Dragoon Creek Hundred and Ten Mile Creek	Pomona
2	Salt Creek drainage area	Salt Creek	-
3	Drainage area of Marais des Cygnes River above confluence of Salt Creek	Marais des Cygnes River	Proposed Melvern
4	Drainage area of Marais des Cygnes River from mouth of Salt Creek to mouth of Bull Creek, excluding Pottawatomie Creek's drainage area	Marais des Cygnes River	-
5	Drainage area of Pottawatomie Creek	Pottawatomie Creek	Proposed Garnett
6	Drainage area of Bull Creek	Bull Creek	Proposed Hillsdale
7	Drainage area of Marais des Cygnes or Osage River from mouth of Bull Creek to mouth of Little Osage River	Marais des Cygnes or Osage River, Miami Creek	Proposed Butler
8	Drainage area of Marmaton and Little Osage River	Marmaton River Little Osage River	Proposed Ft. Scott
9	Drainage are of the Osage River from mouth of Little Osage River to mouth of South Grand River, excluding the drainage areas of Sac River and Pomme de Terre River.	Osage River Clear Creek	Proposed Eldorado Springs
10	Drainage area of Sac River	Sac River	Proposed Stockton Proposed Hackleman Corner
11	Drainage area of Pomme de Terre River	Pomme de Terre River	Pomme de Terre

(continued)

Table IV-1 (continued)

Description of Subareas
Osage River Basin

Subarea	Description	Major Streams	Reservoirs
12	Drainage area of South Grand River	South Grand River	Proposed Freeman Proposed East Branch
13	Drainage area of Osage River above its mouth to mouth of South Grand River	Osage River	Proposed Kaysinger Bluff, Lake of the Ozarks

V. ECONOMY

Present

An assessment of future municipal and industrial and quality control water requirements in the Osage River Basin involves an appraisal of the area's future population and industrial growth potential. The increasing regional and national demand for goods and service affords an opportunity for attracting new industries and expanding existing ones.

To utilize basic economic data which is generally presented by counties, the entire counties of Miami, Franklin, Osage, Anderson, Linn, and Bourbon Kansas, and Cass, Bates, Vernon, Barton, Dade, Cedar, St. Clair, Henry, Benton, Hickory, Polk, Dallas, LaClede, Camden, Miller, Maries, Osage, Greene and Morgan in Missouri were used as the study area for this section of the report.

The total population of the Osage River Basin Study area had decreased from 481,811 in 1910 to 434,776 in 1960. The rural population decreased 38 percent, while the urban population increased 133 percent. The city of Springfield, Missouri increased from 35,201 in 1910 to 95,865 in 1960. For statistical interpretation the entire city of Springfield has been included as part of the study area. Table No. V-1 depicts historical population data for the Osage River Basin Study Area. 1/

Table No. V-1

Population Data for the

Osage River Study Area 1/

Year	1910	1920	1930	1940	1950	1960
Urban*	78,905	86,286	111,424	122,502	137,013	183,661
Rural*	402,906	374,137	338,312	320,950	287,807	251,115
Total	481,811	460,423	449,736	443,452	424,820	434,776

*Bureau of Census Definition

In 1960, of the total labor force (154,178), 60 percent was employed in the services, while 37 percent was employed in the basic categories; the remainder was unemployed. Table No. V-2 depicts employment data for the study area. 2/

Table No. V-2

The Number and Percent of the

Labor Force by Major Classifications in the

Osage River Study Area 2/

Year	1950		1960	
	Number	Percent of Labor Force	Number	Percent of Labor Force
Farm	55,816	35.0	31,005	20.0
Mining	1,539	1.0	879	.5
Manufacturing	14,075	9.0	24,578	16.0
Total Basic	71,430	45.0	56,462	36.5
Total Service	83,767	53.0	92,175	60.0
Unemployed	3,758	2.0	5,541	3.5
Total Labor Force	158,955	100.0	154,178	100.0

Agricultural employment has shown a 45 percent decrease from 55,816 in 1950 to 31,005 in 1960. During the same period the number of farms has also decreased from 51,513 to 38,434. However, the value of farm products sold has increased from $144 million to $197 million (adjusted to the 1954 value of the dollar). Increases in agricultural efficiency, including use of more labor saving machinery, higher yielding crops, and greater use of soil nutrients has been largely responsible for the decreasing labor force and increasing production. Table No. V-3 depicts agricultural data for the study area. 2,3/

Table No. V-3 3/

Agricultural Data for the

Osage River Study Area

Year	Number of Farms	Cropland Harvested (Acres)	Value of all Farm Products Sold* (Dollars)
1949	51,515	2,975,235	144,605,623
1954	45,560	2,872,996	136,935,169
1959	38,434	2,742,493	197,777,057

*Adjusted to the 1954 value of the dollar

The study area contains about 3.0 million acres of forest land with approximately 80 percent in pole timber, seedlings, and saplings. The wood-products industries in the area employed about 2,000 persons in 1960. 4/ The lack of markets for these

products has slowed the utilization of the timber.

Manufacturing employment has increased 75 percent from 14,075 in 1950 to 24,578 in 1960. All industrial categories have been increasing. Manufacturing data are presented in Table No. 4.

Table No. V-4

Employment Data by Manufacturing Categories 2/
for the Osage River Study Area

	1950 Employees		1960 Employees		Percent Increase in Employment 1950 - 1960
	Number	Percent	Number	Percent	
Manufacturing	14,075	100.0	24,578	100.0	75
Furniture, Lumber & Wood Products	1,740	12.0	1,919	8.0	10
Primary Metals	218	2.0	262	1.0	20
Fabricating metals, Machinery, Vehicles, other durables	2,840	20.0	7,431	30.0	162
Food & Kindred Products	3,045	22.0	4,198	17.0	38
Textile & Apparel	2,252	16.0	3,863	16.0	72
Printing & Publishing	1,895	14.0	2,038	8.0	8
Chemicals & Allied Products	220	2.0	569	2.0	159
Non-durables	1,865	12.0	4,298	18.0	130

There are deposits of coal, petroleum, natural gas, stone, clay, and sand and gravel in the study area. The value of minerals extracted has remained relatively stable, receiving $15.7 million in 1956 and about $15.0 million in 1961.

Coal mining contributes the largest share of this income with the Kansas City Power and Light Company, the major consumer. Table No. V 5 depicts the value of minerals extracted annually for 1956 to 1961.

Table No. V-5

Value of Minerals Extracted 5/

Osage River Study Area

(Millions of Dollars)*

	1956	1957	1958	1959	1960	1961
Osage River Basin Study Area	15.7	14.0	13.0	13.4	12.1	15.0

*Adjusted to the 1954 value of the dollar

Future

The population of the Osage River Basin Study Area is expected to reach about 1,200,000 by the year 2060, increasing at the same rate as the population of the respective states as shown by "Senate Select Committee on National Water Resources, Committee Print No. 5, Population Projections and Economic Assumptions." Of this total, 1,000,000 should be urban, and the remaining 200,000 rural. Exhibit No. 2 displays population projections for the Osage River Study Area. 6/

The major portion of this population growth is expected to be in the Springfield, Missouri Standard Metropolitan Statistical Area, reaching a population of 300,000 by 2010 and approximately 600,000 by 2060.

The present pattern of agricultural development should continue with fewer and larger farms. The proportion of the basin's labor force employed in agriculture is expected to continue to decrease from 20 percent in 1960 to 10 percent in 2010 and 5 percent in 2060.

Mining employment in the basin is expected to have relatively small increases, employing about 1,000 persons in 2010 and approximately 2,000 in 2060. The major activity will be in the mining of sand and gravel, used in construction.

Manufacturing is expected to absorb about 25 percent of the labor force in 2060. The total manufacturing employment, principally in the fabricated metals, machinery, vehicles, other durables, food and kindred, non-durables, and textile and apparel categories, should increase from approximately 25,000 in 1960 to about 100,000 in 2060. See Table No. V-6 for employment projections.

Table No. V 6

Projected Employment of Labor Force

Osage River Study Area

Year	2010		2060	
	Number	Percent of Labor Force	Number	Percent of Labor Force
Farm	25,000	10	20,000	5
Mining	1,000	1	2,000	0
Manufacturing	51,500	21	100,500	24
Total Basic	77,500	32	122,500	29
Total Service	160,000	65	285,000	68

(Cont'd)

(Cont'd) Table No. V-6

Projected Employment of Labor Force

Osage River Study Area

Year	2010		2060	
	Number	Percent of Labor Force	Number	Percent of Labor Force
Unemployment	7,500	3	12,500	3
Total Labor Force	245,000	100	420,000	100

VI. WATER RESOURCES OF THE STUDY AREA

Surface Water

Surface water flows in the Osage (Marais des Cygnes) River Basin are of two general categories. (1) Flows in that part of the basin which is west of a line running through Warrensburg in Johnson County, Missouri, and Eldorado Springs in Cedar County, Missouri, are the result of runoff from rainfall in the immediate area. Ground water contributions from springs and seeps are negligible. As shown by the historical streamflows, Exhibit No. 3, there are wide fluctuations in streamflow with minimum flow insufficient to meet the present demands of the area. (2) In that portion of the basin east of the line through Warrensburg and Eldorado Springs, there is a significant ground water contribution which supplements the low flow. There are 16 major springs with flows ranging from 0.26 million gallons per day (mgd) to 7.1 mgd, making a total contribution to surface flow of 42.4 mgd.

In the Kansas portion of the basin, there are presently 19 channel dams and 24 locally owned reservoirs for municipal and industrial water supplies and recreational uses. However, several cities in this upper portion of the basin have had to resort to hauling water by truck or train during the droughts of the last decade.

Ground Water

Ground water in the Osage (Marais des Cygnes) River Basin varies greatly in both quantity and quality from the western to the eastern portion of the basin.

In the western portion of the basin, including Cass and Bates Counties, Missouri, and all counties in the Osage Basin in Kansas,

ground water resources are considered inadequate for municipal and industrial water supplies. The available ground water provides only limited supplies for rural needs. In general, ground water in this area is obtained from sandstone and weathered limestone at shallow depths.

Separating this western part from more abundant supplies to the east is a belt of fresh to brackish ground water 10 to 20 miles in width, extending across the basin on a line from Nevada to Warrensburg, Missouri. The ground water in this area is produced from wells several hundred feet in depth from the Arbuckle group of Ordovician Age. Water from deep wells in this area has mineral concentrations which exceed the maximum limit of the 1962 Public Health Service Drinking Water Standards. A typical analysis of the Nevada, Missouri water supply is an example of this type of water. The total solids are 1529 mg/l and the chloride concentrations are 610 mg/l.

Ground water in the eastern portion of the basin is found in aquifers of Cambrian and Ordovician Age. The water is generally suitable for municipal and industrial supplies, both from a standpoint of quantity and quality. Wells can be expected to yield from 150 to 600 gallons per minute (gpm).

VII. WATER REQUIREMENTS - MUNICIPAL AND INDUSTRIAL

Present

Eighty-nine municipal water systems in the Osage River Basin serve approximately 234,000 persons. The municipal and industrial use averages 21.5 million gallons per day (mgd) at the present time and the average municipal per capita use is 92 gallons per capita per day (gpcd). The 12 largest cities in the basin average 95 gpcd and other municipalities range from 50 to 70 gpcd. The source of this water is almost equally divided between ground and surface sources. See Exhibit 4 in the appendix for a listing of municipal water supplies.

The mineral concentrations in the surface water supplies are below the maximum limits of the Public Health Service Drinking Water Standards. Twelve of the public supplies, from ground water sources, however, have mineral concentrations in excess of the stated standards. See Exhibit No. 5.

Prospective

Needs for dependable water supplies are expected to increase in the Osage Basin based on the projected increase in industrialization, use of new household devices, and improvements in standards of living, along with increased population and the availability of a dependable, good quality source of water. The industrial growth is expected to be that of light industry requiring minor amounts of water and, therefore, the industrial needs are included in the projected municipal per capita figures of water use.

Two projections of future use ranges have been made because of the present difference in per capita use between the large and small communities. This trend should continue in the future. At present, the smaller communities (less than 2,500 population) in the basin use approximatley 70 gpcd and it is expected that per capita use in these communities will rise to 120 gpcd by 2010 and 175 gpcd by 2060.

In the larger communities, urban size or greater, present per capita use is approximately 95 gpcd and it is expected that per capita use will be 175 gpcd by the year 2010 and 225 gpcd by 2060.

The municipal and industrial water requirements are expected to reach approximately 88 million gallons per day by 2010 and 225 mgd by the year 2060. Table No. VII 1 lists the yields from storage needed in 2060 to meet the municipal and industrial requirements in various subareas.

Table No. VII-1

Summary of Yields from Storage Needs
to Meet Municipal and Industrial
Water Requirements (2060)

Osage River Basin

Subarea*	Yield From Storage (mgd)
1,2,3,9,10,11,13	0
4	6
5	1
6	4
7	2
8	5
12 (Harrisonville Area)	1
12 (Freeman Area)	20

*The study area is divided into 13 subareas as shown on the map of the study area.

The above table is based on a 0.02 probability of climatic annual flows being equal to or less than the required flow, i.e., 98 percent protection level.

Most of the streamflow regulation for municipal and industrial water supply needs will be needed during the summer months.

The municipal water supplies of several communities in the basin are of poor quality and of undependable quantity. Some of these communities will probably continue to use their ground supplies since it would be very expensive water from the proposed reservoirs.

In Subareas 1, 2 and 3 both surface and well water are used. Eskridge (1960 population - 519) uses well water with a hardness reported as 787 mg/l (as $CaCO_3$) and total dissolved solids of 1,031 mg/l. Due to the location of this municipality and its small size, it does not appear to be feasible for them to obtain water from the proposed impoundments. The other municipalities in these subareas either have adequate water supplies or it is not feasible to obtain water from the proposed impoundments. Other municipalities in this area are Burlingame (1960 population - 1151), Lyndon (1960 population - 953), Osage City (1960 population - 2213), and Quenoma (1960 population - 434).

In Subarea 4, the major need for municipal and industrial water occurs at Ottawa. The yield from storage in 2060 is shown in Table No. VII-1 for Subarea 4. The year of first need is 1980.

There is a need for water storage for municipal and industrial

water supply by 2010 in Subarea 5. The yield from storage in 2060 for Subarea 5 is shown in Table No. VII 1 and is needed above Garnett.

In Subarea 6, the need for water storage for municipal and industrial water supply occurs primarily in the areas near the Hillsdale Reservoir. Communities in this area that may need water are Paola, Gardner, Wellsville, Edgerton, Spring Hill, Bucyrus and Hillsdale. The 2060 yield from storage for Subarea 6 is shown in Table No. VII 1. It is needed in the beginning of the study period.

In Subarea 7 Butler has an impoundment and needs additional water. A yield from storage for Subarea 7 is shown in Table No. VII 1. Rich Hill has a highly mineralized well supply (1,937 mg/l total dissolved solids). A satisfactory quality surface water is available in the Marais des Cygnes River. Based on a climatic annual 98 percent protection level the uncontrolled streamflow is ample to meet the projected needs of Rich Hill and Butler.

In Subarea 8 the need for regulation for municipal and industrial water supply occurs at Fort Scott and Nevada. The 2060 yield from storage for Subarea 8 is shown in Table No. VII 1. The year of first need is 2010.

In Subarea 9, Schell City has a highly mineralized well supply (836 mg/l total dissolved solids). A satisfactory quality surface water is available in the Osage River. Based on a 98 percent climatic annual protection level, there is an ample supply of uncontrolled stream flow to meet the projected needs of Schell City.

Based on present information, the water supplies in Subarea 10 and 13 are adequate in quality and quantity to meet present and projected needs.

In Subarea 11, Hermitage, Urbana and Wheatland are small communities, (1960 populations of 304 to 348) that have well supplies of marginal quality. If these communities should decide to improve their water supplies by using surface water they could use water from Pomme de Terre River, Lake Pomme de Terre, and Pomme de Terre River, respectively. Based on a 98 percent protection level there is an ample supply of water from these sources to meet their projected needs.

In Subarea 12 Deepwater (1960 population 712) has a highly mineralized well supply (2048 mg/l total dissolved solids) and Harrisonville (1960 population 3,510) has a surface water supply. Surface water having a satisfactory water quality is available in the South Grand River. Based on a 98 percent protection level there is an ample supply of uncontrolled streamflow to meet the projected needs of Deepwater. Harrisonville uses water from impoundments in the headwaters drainage area of the South Grand River. The present water supply meets present demands.

The projected increase in water demands of Harrisonville combined with reservoir silt accumulation is expected to result in a future water shortage in about the year 1990. When an additional water source becomes necessary, additional reservoirs could be constructed. Also, there are possibilities that water could be obtained from either the Kansas City Water Department or from the authorized Kaysinger Bluff reservoir.

Value of Storage

When no adequate means can be devised to evaluate directly the economic value of water for municipal and industrial use, the cost of the alternate most likely to be used in the absence of the project which will yield the same amount of water of equal quality delivered to the same point of need is used as an approximation of the value. An interest rate of 4 percent is used in amortizing the capital cost and 3 1/8 percent interest is used in discounting. This is shown in Exhibit No. 7.

Subarea 4

The alternative studied for Subarea 4's needs were: a single purpose reservoir in Subarea 1 at the Pomona Reservoir site; a single purpose reservoir in Subarea 3 at the Melvern Reservoir site; a dual purpose reservoir, for quality control and municipal and industrial needs, in Subarea 1 at the Pomona site; a dual purpose reservoir in Subarea 3 at the Melvern Reservoir site; and development of ground water in Subarea 4 to meet the municipal and industrial water supply needs. For Subarea 4, the most feasible alternative was found to be a single purpose reservoir in Subarea 3 at the Melvern Reservoir site. This single purpose reservoir is first needed by the year 1980. The annual value of storage for municipal and industrial water supply needs is the annual value of this single purpose reservoir which is discounted from 1980, is $50,000. See Exhibit No. 7 in the appendix.

Subarea 5

The alternatives studied for Subarea 5 were the development of

ground water to meet projected needs, a single purpose reservoir at the Garnett Reservoir site, and a dual purpose reservoir at the Garnett site. The most feasible alternative was found to be the single purpose reservoir at the Garnett Reservoir site which is needed by the year 2010. The annual value of this single purpose reservoir which is the annual value of storage for municipal and industrial water supply needs is $7,100, discounted from 2010.

Subarea 6

Development of the ground water resources in Subarea 6 was considered as an alternative to flow regulation. A single purpose and a dual purpose reservoir at the Hillsdale Reservoir site were considered as two separate alternatives for Subarea 6. The most feasible alternative for Subarea 6 was found to be the single purpose reservoir. This single purpose reservoir is needed now. The annual value of storage for municipal and industrial water supply needs is the annual value of this single purpose reservoir which is $121,000.

Subarea 7

The alternatives considered for this subarea were ground water, single purpose reservoirs, and a pumping system to get water from the Osage River. The most feasible alternative was found to be the pumping system. The year of first need is 1960. An additional pipeline will be needed in 2010. The annual value of this alternative is estimated at $18,300.

Subarea 8

A dual purpose and a single purpose reservoir at the Fort Scott

Reservoir site were considered as two alternatives in Subarea 8. The most feasible alternative for a municipal and industrial water supply in Subarea 8 would be the single purpose reservoir at the Fort Scott Reservoir site. The annual value of this single purpose reservoir which is the annual value of storage for municipal and industrial water supply needs is $18,700. A more detailed study of this subarea can be found in Water Resources Study Marmaton River Basin Kansas and Missouri, a study by U. S. Department of Health, Education and Welfare in March, 1964 for the Department of the Army.

Subarea 12
(Harrisonville Area)

The alternatives considered for the Harrisonville area were both ground and surface water sources. A single purpose reservoir on East Branch of the Grand River upstream from Harrisonville was found to be the most feasible alternate to meet the municipal and industrial water needs of the area. The needs from the reservoir were based mainly on the increased demands at Harrisonville, but it was assumed that nearby communities might also want water from this source. Adrian, Freeman, Garden City, and Peculiar all use surface impoundments as a source of raw water and all may need to supplement their raw water sources in the future. This single purpose reservoir has an estimated construction cost of $1,000,000 and an annual operation and maintenance cost of $8,000. The 1960 worth of the annual cost is $17,500 based on a year of first need in 1990. See Exhibit No. 7 in the appendix.

Subarea 12
(Freeman Area)

Ground and surface water sources were considered as an alternative to meet the future municipal and industrial water needs in this area. It has been estimated that the growth of Kansas City, Missouri to the south will result in additional water needs that could be met by using water storage on the South Grand River near Freeman, Missouri. The most feasible alternative is a single purpose reservoir near Freeman. The reservoir has an estimated cost of $7,600,000, an annual operating cost of $25,000 and the year of first need is 1980. The 1960 worth of annual cost is $161,600. See Exhibit No. 7 in the appendix.

VIII. WATER QUALITY CONTROL

Present

The 59 sewerage systems in the study area serve an estimated 132,000 persons. Industrial waste discharge to the systems increases the waste loadings to approximately 161,000 population equivalent (P.E.) per day (0.25 lbs. ultimate BOD is equal to 1 P.E.) The equivalent of secondary treatment is provided by most of the systems and therefore the organic material removal efficiency of the plants in the study area average out to approximately 86 percent (BOD removal) resulting in a discharge of 21,600 P.E. or approximately 5,400 pounds per day of ultimate first stage Biochemical Oxygen Demand (BOD) to the streams in the basin.

Prospective

The pollutional effect of waste discharges on a receiving stream is a function of a number of variables. The main assumptions used in evaluating the need for quality control storage or regulation in the Osage (Marais des Cygnes) River Basin are as follows:

1. Waste discharged to the streams of the basin will continue to be primarily organic in nature and specific mineral and/or organic toxicants will not be a significant problem.

2. Organic waste loads amounting to 0.25 lbs. of ultimate first stage BOD per P.E., per day, will receive treatment removing 85 percent of the oxygen demand. Return flows will amount to 70 percent of water use. Industrial wastes are considered to be included in the above values.

3. Considering the needs for water and the cost of providing this

water, it was decided that a degree of protection of 90 percent, would be reasonable for this area, i.e., with streamflow regulation there will be sufficient streamflow to fully meet the governing goals 9 years out of 10 on an average.

4. Maintenance of a level of 5 mg/l dissolved oxygen in receiving waters will provide adequate protection of aquatic life. This is in accordance with the objectives of the Missouri Basin Engineering Health Council.

5. Quality control needs were based on three different periods. The summer period will be five months long and have an average water temperature of 24° C. The spring and fall periods will be three months long and have an average temperature of 12° C. The winter period will be four months long and have an average water temperature of 2° C. These are average temperatures and were used in the calculations in determining water storage needs for streamflow regulation for quality control. During reservoir operations the water temperatures will vary and the streamflow regulation requirements will vary with temperature changes.

6. The installation of multiple outlets in deeper reservoirs will be necessary in order to avoid the degradation of downstream water quality by poor quality reservoir releases. Where thermoclines develop, water withdrawn from the hypolimnion is cold and may be devoid of oxygen.

Table No. VIII-1

Waste Loading Projection Factors

Factor	1960	2010	2060
Organic Load (lbs. of ultimate first stage BOD per capita per day)	0.25	0.25	0.25
BOD Removal Efficiency (Percent)	85	85	85
Municipal Waste Flows (Urban) gpcd	84	123	158
Municipal Waste Flows (Less than Urban) gpcd	49	84	123

Water quality flow requirements at the major pollution sources of Butler, Eldorado Springs, Fort Scott, Garnett, Harrisonville, Nevada, Osawatomie, Osawatomie State Hospital, Ottawa, and Paola were determined on the basis of oxygen sag calculations.

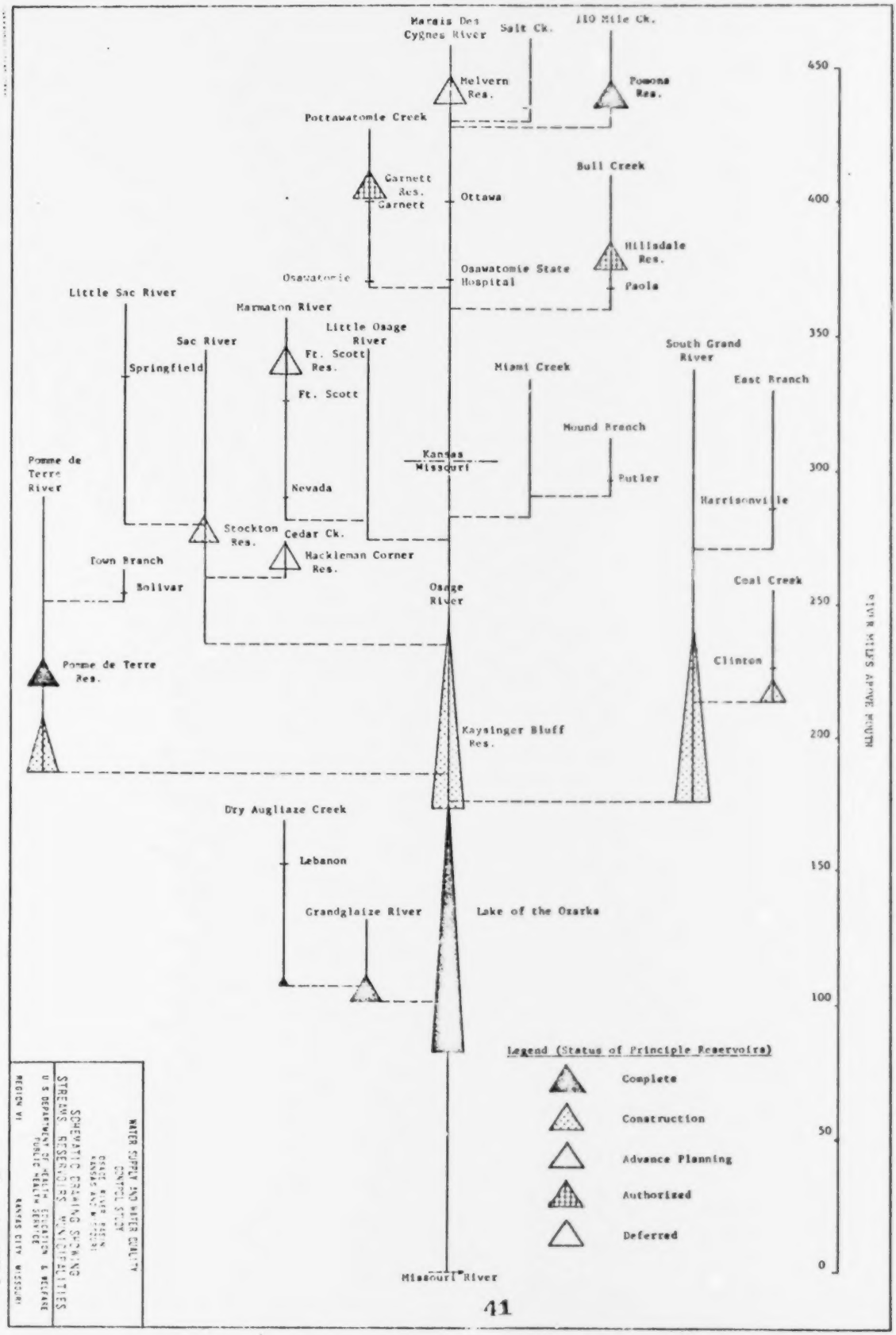
Considering quality control needs, municipal returns, and natural runoff (based on the 90 percent protection level), Table No. VIII-2 lists the annual draft on storage needed in 2060 to maintain the quality control needs. A schematic diagram of the river systems is shown in Figure No. VIII-1.

Table No. VIII-2

Summary of Net Regulation Requirements
in Acre-Feet Per Year in 2060
Osage River Basin

Subarea*	Annual Draft on Storage (Acre-Feet)
4	12,200
5	600
6	9,100
7	6,600
8	11,200
9	2,800
12	1,900

*The study area is divided into 13 subareas as shown on the map of the study area.


Marais Des Cygnes River
Salt Ck.
110 Mile Ck.
Melvern Res.
Pomona Res.
Pottawatomie Creek
Garnett Res.
Garnett
Ottawa
Bull Creek
Hillsdale Res.
Osawatomie
Osawatomie State Hospital
Paola
Little Sac River
Marmaton River
Little Osage River
Sac River
Springfield
Ft. Scott Res.
Ft. Scott
Miami Creek
South Grand River
East Branch
Mound Branch
Kansas
Missouri
Pomme de Terre River
Nevada
Butler
Harrisonville
Stockton Res.
Cedar Ck.
Hackleman Corner Res.
Town Branch
Bolivar
Osage River
Coal Creek
Pomme de Terre Res.
Clinton
Kaysinger Bluff Res.
Dry Auglaize Creek
Lebanon
Grandglaize River
Lake of the Ozarks
Missouri River
450
400
350
300
250
200
150
100
50
0
Miles Above Mouth
Legend (Status of Principle Reservoirs)
Complete
Construction
Advance Planning
Authorized
Deferred

The regulation requirements are based on adequate water quality monitoring. Most of the streamflow regulation for water quality control will be needed during the summer months. Some problems may arise from pollution loads entering the reservoirs and special studies or investigations may be needed. Minimum streamflow needed at major points of needs within the basin are shown on Table VIII-3.

Table VIII-3

Minimum Streamflows for Quality Control
(Flow in cfs)
Osage River Basin

Area	1960			2010			2060		
	/Spring/ Summer/	& Fall/	Winter	/Spring/ Summer/	& Fall/	Winter	/Spring/ Summer/	& Fall/	Winter
Subarea 4 (Ottawa)	12	6	4	24	9	4	50	15	7
Subarea 4 (Osawatomie)	18	9	5	30	10	5	57	16	5
Subarea 5 (Garnett)	3	2	1	6	3	1	12	4	2
Subarea 6 (Paola)	6	3	1	12	4	2	24	8	3
Subarea 7 (Butler)	3	2	1	7	3	1	15	5	2
Subarea 8 (Ft. Scott)	11	4	2	23	8	4	38	15	9
(Nevada)	18	7	3	37	13	4	65	26	8
Subarea 9 (Eldorado Springs)	5	3	2	9	3	2	15	6	3
Subarea 12 (Harrisonville)	3	2	1	6	3	1	12	4	2

The above flows are the total requirements including natural runoff supplemented by reservoir releases.

The 2060 drafts on storage required in each subarea are shown in Table VIII-2.

In subarea 4, there is an immediate need for flow regulation

to maintain water quality at Ottawa.

In Subarea 5, the need for quality control regulation occurs at Garnett. It is estimated that flow regulation will first be needed in 2040.

There is presently a need for quality control regulations in Subarea 6 at Paola.

There is presently a need for quality control regulations in Subarea 7. The 2060 draft on storage shown in Table No. VIII-2 is needed on Miami Creek above Mound Branch which receives Butler's waste.

There is presently a need for quality control regulation in Subarea 8 at Fort Scott and Nevada.

In Subarea 9, the need for quality control regulation occurs where Eldorado Springs' effluent reaches Clear Creek. At this point regulation for quality control is presently needed.

There is a present need for regulation for quality control in Subarea 12. The 2060 draft on storage shown in Table VIII-2 is needed on East Branch South Grand River above the point at which Harrisonville's waste enters the stream.

In other subareas there are needs for quality control regulation. These needs are not shown since they occur on the periphery of the drainage basin of the Osage River and none of the proposed reservoirs could economically supply the needed regulation. Nor does it seem feasible that a reservoir for quality control could be located above such municipalities as Springfield or Lebanon because of limited drainage areas.

Benefits

The benefits to be derived from storage for streamflow regulation for water quality control may be tangible, i.e., may have a measurable dollar value; or may be intangible with no measurable dollar value. The amount of tangible benefits are based on comparison with the cost of the most economical, acceptable alternative.

Assured water quality will provide favorable conditions for recreation such as swimming, water skiing, boating, and fishing for those living in the Osage River Basin and those in nearby areas. The total population of the economic study area is estimated to be in the order of 1,200,000 by 2060. It is not unreasonable to anticipate that the total population in the study area plus all the people located in the Kansas City SMSA will be able to enjoy the recreational opportunities offered.

In addition to recreational benefits, riparian property owners will enjoy improved esthetics of the stream stemming from unpolluted surface waters and a satisfactory public health environment. The impoundments will have a beneficial effect on the mineral solids content of the waters of the controlled streams, which could lower treatment costs. 22/

From the above, it is concluded that benefits are widespread in scope and sufficient in magnitude to justify the provision of the volume of storage necessary for the required streamflow regulation. These benefits may be credited to storage for the regulation of streamflow for water quality control purposes only if assurance is given that adequate treatment will be provided.

The designated drafts on storage for each subarea are those required

to maintain 5 mg/l dissolved oxygen on an average of 9 years out of 10 (90 percent protection level). In areas now requiring flow regulation, the oxygen levels presently fall below this minimum requirement. This factor has resulted in a decrease or depletion of game fish and the prominence of rough fish.

The State of Kansas Forestry, Fish and Game Commission states:

> "Considerable stream fishing occurs where public access is permitted along the streams. Much of the fishing occurs just below the overflow dams which are numerous in this basin. The future outlook for stream fishing will be determined by the extent to which public fishing is allowed. The Forestry, Fish and Game Commission is initiating plans to acquire easements on limited areas to provide access for public fishing.
>
> "Reservoir fishing opportunities will be considerable increased as the federal reservoirs (Melvern, Hillsdale, Garnett and Ft. Scott reservoirs) are completed, provided water is available for stabilizing the permanent pools in these impoundments. Stream habitat and fish populations could be greatly improved if minimum flows could be augmented to provide conditions throughout the years satisfactory for fishlife. The soil conservation measures applied to the watersheds, and the operation of federal reservoirs, should also aid in producing less erosion and less turbidity in the water, and this would improve habitat conditions for fish."

The Missouri Conservation Commission states that the Osage River Basin streams in Missouri have sluggish flow with turbid water and that the fish populations are mainly rough species. Streamflow regulation for quality control will maintain the desired oxygen concentrations which will benefit the fishery by making more water available when required during the critical months usually in late summer.

If required storage for streamflow regulation is not provided as recommended, water treatment costs in the area may be expected to increase, damage to paint on structures adjacent to or in the streams may be anticipated, and property values will decline in areas con-

tiguous to the streams. Recreation will suffer. Without streamflow regulation it is estimated that the projected waste loads will result in oxygen concentrations of 0 to 2 mg/l by 2010 in all of the subareas presently needing streamflow regulation for quality control. By 2060 all of these areas will have periods of zero oxygen levels, in which the fish will not be able to survive. These oxygen depleted waters will be a source of noxious odors with paint blackening fumes and the streams will be worthless for recreational purposes. Unless adequate treatment is supplemented by streamflow regulation, unsatisfactory conditions will occur in subareas 4, 5, 6, 7, 8, 9 and 12. These areas are shown on the study area map at the back of the report.

Value of Benefits

When no adequate means can be devised to evaluate directly the economic effects of water quality maintenance or improvement, the cost of achieving the same results by the most likely alternative may be used as an approximation of value. The most likely alternative possibilities studied in each case are described below, from which the most economical alternative has been selected. An interest rate of 3-1/8 percent was used to determine the average annual value. These computations are summarized in Exhibit No. 8.

Subarea 4

The alternatives studied for Subarea 4's needs were: a single purpose reservoir in Subarea 1 at the Pomona site; a single purpose reservoir in Subarea 3 at the Melvern site; a dual purpose reservoir, for both quality control and municipal and industrial needs, in Subarea 1

at the Pomona site; a dual purpose reservoir in Subarea 3 at the Melvern site; and holding ponds at Ottawa and Osawatomie, that would enable these two municipalities to control their waste releases. For Subarea 4, the most feasible alternative was found to be the single-purpose reservoir in Subarea 3 at the Melvern site. The annual value of quality control regulation, which is presently needed in Subarea 4, based on the annual value of this single purpose reservoir, is $82,100.

Subarea 5

The alternatives studied for Subarea 5 were a single purpose reservoir at the proposed Corps of Engineers Garnett Reservoir site, a dual purpose reservoir at the same site, and a holding pond at Garnett. The most feasible alternative for Subarea 5 was found to be the holding pond at Garnett. This holding pond would first be needed in 2040. The annual value of quality control regulation in Subarea 5 based on the annual value of this holding pond is $500.

Subarea 6

A single purpose and a dual purpose reservoir at the proposed Corps of Engineers Hillsdale Reservoir site were considered as two separate alternatives for Subarea 6. A holding pond at Paola was also considered as an alternative. The most feasible alternative for Subarea 6 was found to be a single purpose reservoir. The annual value of quality control regulation in Subarea 6, which is presently needed, is the annual value of this single purpose reservoir which is $95,200.

Subarea 7

The alternatives studied for Subarea 7 were a single purpose

reservoir on Miami Creek above Butler at a site considered by the Corps of Engineers, pumping the waste to the Osage River, and pumping the waste to Miami Creek and a holding pond there. The most feasible alternative for achieving the desired quality in Miami Creek is the single purpose reservoir. The annual value of this reservoir which is now needed is $56,000.

Subarea 8

The alternatives studied for Subarea 8 included a single purpose reservoir at the proposed Corps of Engineers Fort Scott Reservoir site, a dual purpose reservoir at the same site, and holding ponds at Fort Scott and Nevada. In this case, the most likely alternative is a single purpose reservoir at the proposed Fort Scott site which will provide the needed 11,200 acre feet/year draft on storage. The annual value of quality control regulation which is needed now is the annual value of this single purpose project which is $76,000. This subarea was studied by the U. S. Department of Health, Education and Welfare for the Department of the Army and was published in March, 1964, as Water Resources Study - Marmaton River Basin - Kansas and Missouri.

Subarea 9

A single purpose reservoir on West Fork Clear Creek at a site being studied by the Corps of Engineers and pumping Eldorado Springs' waste to the Osage River were two alternatives studied for Subarea 9. The most feasible alternative in Subarea 9 was the single purpose reservoir to provide adequate flow to assimilate Eldorado Springs' waste. The value of quality control regulation which is presently needed in Subarea 9 is $63,000 per year.

Subarea 12

Two alternatives were studied for Subarea 12, pumping Harrisonville's waste to below the confluence of East Branch South Grand and the South Grand River with holding pond and a single purpose reservoir at a Corps of Engineers site under study on East Branch South Grand River. The most feasible alternative for Subarea 12 was found to be the single purpose reservoir. The value of quality control regulation in Subarea 12, which is presently needed is $46,000 per year.

Subareas 10, 11, 13

These subareas were studied in March 1962 by the U. S. Department of Health, Education and Welfare for the Department of the Army and published as "Preliminary Report on Water Supply and Pollution Control Aspects of the Kaysinger Bluff Dam and Reservoir (Osage River Basin)."

Section XI of the Kaysinger Bluff report applies to this report and is shown below:

"XI. Strip-Mine Drainage

> Several streams in western Missouri and eastern Kansas have been contaminated by acid wastes from strip mines. In a report by H. J. Fisher, Biologist, Missouri Conservation Commission, based on a 1951 survey, he states: 'About 169 miles of streams in the Osage River drainage basin also have received considerable contamination by strip-mine discharge. Streams, so polluted, in this basin include: Tebo Creek in Henry and Johnson Counties, Marshall Creek, Dillon Creek, Dumpling Creek, Sparrow Creek, and Deepwater Creek in Henry County; Monegaw Creek and Cooper Creek in St. Clair County; Clear Creek, Willow Branch, Robinson Creek, Drywood Creek, and Big Drywood Creek in Vernon County; Big Drywood Creek in Barton County; Walnut Creek and Marais des Cygnes River in Bates County.' Pools of acid-water might form if water in a reservoir backs up into these streams. Upstream reservoirs will permit streamflow control which should result in a better continuous dilution of the acid drainage in the main stem.

"Since strip-mine drainage could discourage full economic development, new mines are worked in such a manner that they produce a minimum of acid-water drainage. In order to reduce the acid-water drainage from areas previously mined, they are being reworked by covering the acid-forming material and by leveling the land."

IX. BIBLIOGRAPHY

1. Bureau of Census, U. S. Census of Population: 1930, 1960, Volume I, "Number of Inhabitants," Government Printing Office, Washington: 1931, 1961

2. Bureau of Census, U. S. Census of Population: 1940, 1950, 1960, Volume II, "Characteristics of the Population," Government Printing Office, Washington: 1942, 1952, 1962.

3. Bureau of the Census, U. S. Census of Agriculture: 1949, 1954, 1959, Volume I, "Area Statistics," Government Printing Office, Washington: 1950, 1955, 1960.

4. Bureau of Mines, Minerals Yearbook: 1933, 1955, 1957, 1959, 1960, Volume III, "Area Report," Government Printing Office, Washington: 1954, 1956, 1958, 1960, 1961.

5. Bureau of Census, U. S. Census of Manufactures: 1949, 1954, 1959, Volume I, "Area Statistics," Government Printing Office, Washington: 1951, 1956, 1961.

6. U. S. Congress, Senate, Select Committee on Natural Resources, Water Resource Activities in the United States, Committee Print No. 5, "Population Projections and Economic Assumptions," Government Printing Office, Washington: 1960.

7. Missouri Division of Health, Census of Public Water Supplies in Missouri, 1962, State Printing Office, Jefferson City: 1963.

8. Missouri Forest Facts, Missouri Forest Industries Committee, St. Louis, Missouri, 1960 Edition.

9. Kansas Water Resources Board, State Water Plan Studies, Part A, Preliminary Appraisal of Kansas Water Problems, Section 1, "Marais des Cygnes Unit," State Printing Office, Topeka, Kansas, June 1958.

10. Corps of Engineers, Multiple-Purpose Project, Pomme de Terre Dam & Reservoir, Osage River Basin, Pomme de Terre River, Missouri, Design Memorandum No. 3, Hydrology, Kansas City District Office, June 1953.

11. Corps of Engineers, Multiple-Purpose Project, Pomona Dam & Reservoir, Marais des Cygnes River Basin, Hundred and Ten Mile Creek, Kansas, Design Memorandum No. 1, Hydrology, Kansas City District Office, September 1957.

12. Public Health Service, A Report of Water Pollution in the Osage (Marais des Cygnes) - Gasconade Drainage Basins," Missouri Drainage Basin Office, Kansas City, March 1952. (Water Pollution Series No. 26)

13. Public Health Service, 1962 Inventory, Municipal Waste Facilities, A Cooperative State-Federal Report, Volume 6, Government Printing Office, Washington: 1963.

14. Public Health Service, Municipal Water Facilities Inventory as of January 1, 1963, Region VI, Unpublished Records, Kansas City, Missouri.

15. Geological Survey, Compilation of Records of Surface Waters of the United States through September 1950, Part 6-B,"Missouri River Basin below Sioux City, Iowa," Government Printing Office, Washington: 1958.

16. Geological Survey, Surface Water Supply of the United States, 1950-1960, Part 6-B, "Missouri River Basin below Sioux City, Iowa," Government Printing Office, Washington: 1958-1961.

17. Soil Conservation Service, Watershed Work Plan, Frog Creek Watershed, Coffey and Osage Counties, Kansas, Government Printing Office, Lincoln, Nebraska: December 1960.

18. Corps of Engineers, Review Report on Additional Conservation Storage and Power Installation in the Authorized Kaysinger Bluff Reservoir, Osage River, Missouri, Kansas City District Office, December 1961.

19. Corps of Engineers, Report on Economic Reevaluation of the Osage River Basin Program (Kansas and Missouri), Kansas City District Office, October 1961 Rev. June 1962.

20. Technical Reports prepared cooperatively by the Kansas Water Resources Board and the U. S. Geological Survey and Published by the State of Kansas:

Technical Report No. 1 - Kansas Streamflow Characteristics, Part 1, "Flow Duration," By L. W. Furness.
Technical Report No. 2 - Kansas Streamflow Characteristics, Part 2, "Low-Flow Frequency," By L. W. Furness.
Technical Report No. 3 - Kansas Streamflow Characteristics, Part 3, "Flood Frequency," By D. W. Ellis, and G. W. Edelen.
Technical Report No. 4 - Kansas Streamflow Characteristics, Part 4, "Storage Requirements to Sustain Gross Reservoir Outflow," By L. W. Furness.

21. Kansas State Board of Health, Chemical Quality of Surface Waters in Kansas, 1957-1960, compiled and published by the Kansas State Board of Health, Division of Sanitation, 1960.

22. Missouri Water Pollution Board, Chemical Quality of Missouri Surface Water, Prepared Cooperatively by U. S. Geological Survey, 1964.

Exhibit No. 1

Major Impoundments in the Osage River Basin

Osage River Basin Study (Kansas and Missouri)

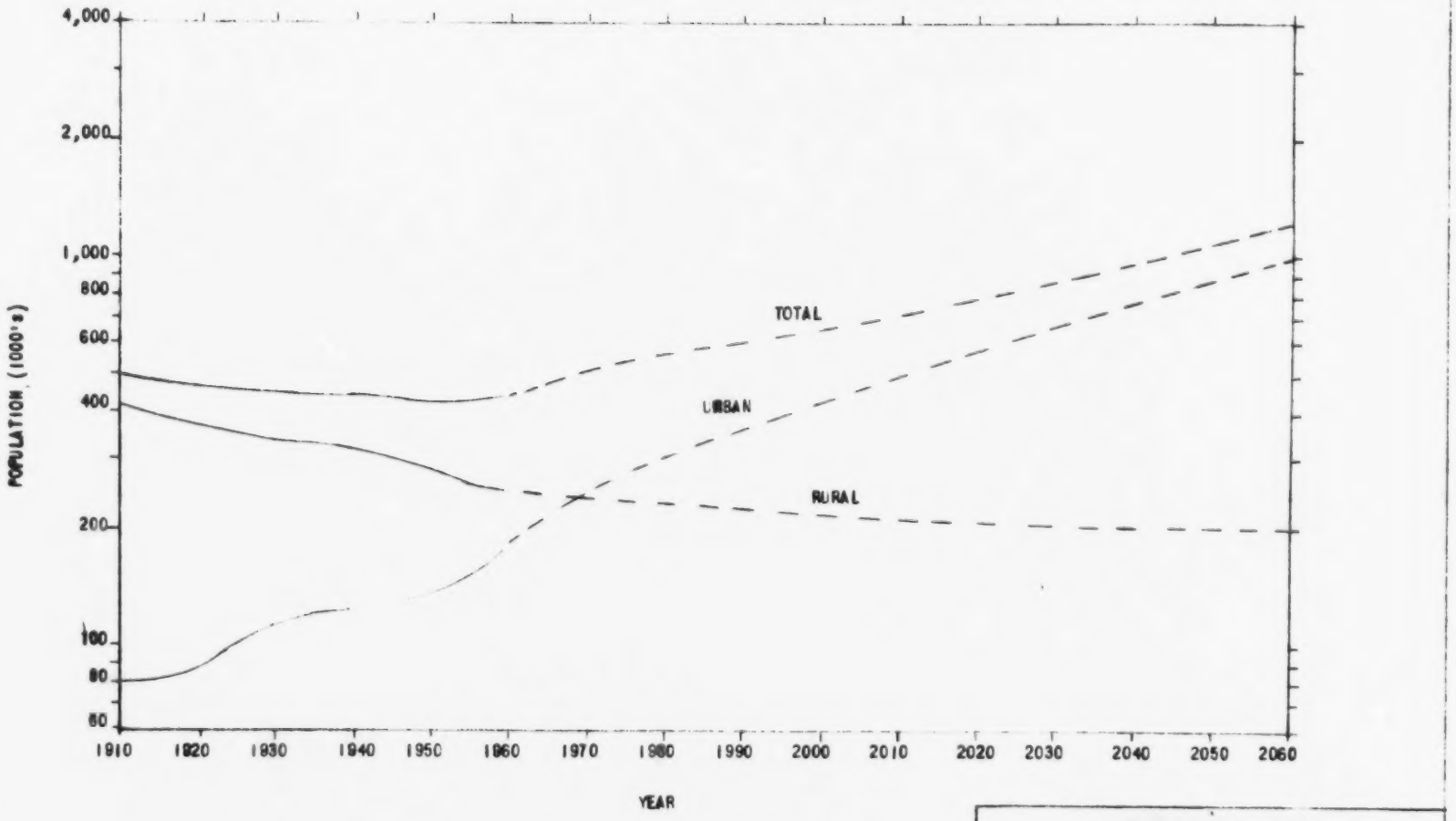
Reservoir Name	Primary Agency	Status	Location (River Mile)	Conservation Pool Acre-Feet	Flood Control Acre-Feet	Sediment Acre-Feet	Total Pool Acre-Feet
Bagnell	UECofMo.1/	Complete	O-82	2,087,000 2/	-	-	2,087,000
Fort Scott	CofE	Advance planning	O-274,LO-18,M-35	74,000 3/	134,000	9,000	217,000
Garnett	CofE	Authorized	O-367,PC-41	18,000 3/	160,000	8,000	186,000
Hackleman Corner	CofE	Deferred	O-235,S-29,CC-3	-	212,300	7,700	220,000
Hillsdale	CofE	Authorized	O-360,BC-15	7,250 3/	77,000	5,750	90,000
Kaysinger Bluff	CofE	Construction	O-175	1,040,000 2/	3,918,000	244,000	5,202,000
Melvern	CofE	Advance planning	O-442	137,000 4/	200,000	26,000	363,000
Pomme de Terre	CofE	Complete	O-187,PT-38	230.000 2/	407,000	13,000	650,000
Pomona	CofE	Complete	O-424,110-MC-7	56,000 5/	162,500	28,000	246,500
Stockton	CofE	Construction	O-235,S-50	875,000 2/	774,000	25,000	1,674,000

1/ Union Electric Company of Missouri.
2/ Conservation pools are allocated for hydroelectric potential and recreation.
3/ Storage tentatively allocated to municipal and industrial water supply, flow augmentation for quality control, and recreation. Specific allocations for each purpose not yet determined.
4/ 90,000 acre-feet for low flow supplementation; 47,000 acre-feet to maintain a minimum pool for recreation.
5/ 1,000 acre-feet for municipal and industrial water supply; 55,000 acre-feet for low flow supplementation.

O - Osage River LO - Little Osage River M - Marmaton River PC - Pottawatomie Creek S - Sac River

CC - Cedar Creek BC - Big Bull Creek PT - Pomme de Terre 110-MC - One Hundred Ten Mile Creek

7/23/63



WATER SUPPLY AND
WATER QUALITY CONTROL STUDY
OSAGE RIVER BASIN
(KANSAS AND MISSOURI)
POPULATION TRENDS & PROJECTIONS

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VI KANSAS CITY, MISSOURI

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Exhibit No. 2

Exhibit No. 3

Historical Streamflow Records

Osage River Basin Study (Kansas and Missouri)

Station	Location	River Mile*	Drainage Area Square Miles	Years of Record	Flows in cfs Maximum	Minimum	Averag
Marais des Cygnes River at Melvern, Kansas	3 miles west of Melvern	O-445.7	351	24	68,500	0	198
Salt Creek near Lyndon, Kansas	2½ miles east of Lyndon	SC-12.6	111	24	36,400	0	61.
Dragoon Creek near Burlingame, Kansas	3 mi. S. of Burlingame	DC-31	114	3	10,500	0	-
Switzler Creek at Burlingame, Kansas	40 miles upstream from mouth	SwC-4	26.3	6	4,800	0	7.
110 Mile Creek near Quenemo, Kansas	4.5 miles northwest of Quenemo	110-MC-7.7	321	24	38,600	0	176
Marais des Cygnes near Ottawa, Kansas	½ mile east of Ottawa	O-398.9	1,250	47	142,000	0	624
Pottawatomie Creek near Garnett, Kansas	4 miles north of Garnett	PC-40.7	334	24	57,000	0	220
Big Sugar Creek at Farlinville, Kansas	At Farlinville, Kansas	BSC-21.1	198	15	37,600	0	125
Marais des Cygnes River at Ks-Mo. State Line	1.7 miles downstream from Big Sugar Creek	O-313.5	3,230	5	57,400	0.9	1,927
Little Osage River at Fulton, Kansas	3/4 mi. N. of Fulton	LO-42	295	14	20,700	0	194
Marmaton River near Fort Scott, Kansas	1 mi N. of Fort Scott	M-33.5	393	37	38,100	0	295

Exhibit No. 3

Exhibit No. 3 (Cont'd)

Historical Streamflow Records

Osage River Basin Study (Kansas and Missouri)

Station	Location	River Mile*	Drainage Area Square Miles	Years of Record	Flows in cfs		
					Maximum	Minimum	Average
Sac River near Stockton, Missouri	2 mi. E. of Stockton	S-62	1,160	42	120,000	0	1,006
Cedar Creek near Pleasant View, Missouri	1½ mile north of Pleasant View	CC-5 3/4	420	18	33,900	0	282
Osage River at Osceola, Missouri	1 mile northeast of Osceola	O-230.9	8,220	44	146,000	3.6	5,137
Pomme de Terre River near Bolivar, Missouri	5½ mi. E of Bolivar	P-64	225	13	18,300	0.1	163
Lindley Creek near Polk, Missouri	2½ miles northeast of Polk	LC-16	112	6	23,000	0	91.8
Pomme de Terre River at Hermitage, Missouri	½ mi. E. of Hermitage	P-21	655	42	70,000	0	599
South Grand River near Brownington, Missouri	200 feet downstream from Deepwater Creek	G-30	1,660	42	63,900	0	1,038
Niangua River near Decaturville, Missouri	8 miles northwest of Decaturville	N-16	627	34	33,400	6.0	638
Osage River near Bagnell, Missouri	1½ mile upstream from Bagnell	O-48	14,000	83	220,000	220	9,581
Osage River near St. Thomas, Missouri	0.5 miles downstream from Sugar Creek	O-22	14,500	32	216,000	346	9,936
Maries River at Westphalia, Missouri	3/4 mile southeast of Westphalia	Mar-4	257	15	20,000	0.1	200

*River miles are approximate

O - Osage (Marais des Cygnes)
SC - Salt Creek
DC - Dragoon Creek
SwC - Switzler Creek
110-MC - 110-Mile Creek
PC - Pottawatomie Creek
BSC - Big Sugar Creek
LO - Little Osage River
M - Marmaton River
S - Sac River
CC - Cedar Creek
P - Pomme de Terre River
LC Lindley Creek
G Grand River
N - Niangua River
Mar - Maries River

Exhibit No. 3 (2)

Exhibit No. 4

Municipal Water Supplies

Osage River Basin Study (Kansas and Missouri)

Location	Population 1960	Population Served 1963	Water Treatment	Source of Supply	Average Plant Output MGD	Estimated GPCD
KANSAS						
Arcadia	507	480	Iron Removal, Chlorination	Deep wells	0.03	63
Arma	1,296	1,500	Softening, Chlorination	Deep wells	0.071	47
Baldwin City	1,077	1,450	Chlorination	Wells & Springs	0.140	97
Blue Mound	319	300	Filtration, Chlorination	Impoundment	0.02	67
Bronson	354	400	Filtration, Chlorination	Impounding Reservoir	0.03	75
Burlingame	1,151	1,125	Coagulation, Odor Control, Chlorination	Dragoon Creek Impoundment	0.09	80
Edgerton	414	380	Coagulation, Chlorination	Impoundment	0.03	79
Eskridge	519	540	Chlorination	Wells	0.035	65
Fontana	138	150	Chlorination	Shallow well	0.01	67
Fort Scott	9,410	10,500	Coagulation, Chlorination, Fluoridation, Softening, Odor Control	Marmaton River, Lake Ft. Scott, Rock Creek Lake	1.30	124
Fulton	207	200	Chlorination	Shallow wells	0.01	50
Gardner	1,619	1,575	Coagulation, Chlorination, Odor Control	Lake Gardner	0.15	95
Garnett	3,034	3,125	Coagulation, Chlorination, Fluoridation, Softening, Odor Control	Cedar Creek (Imp.) and Lakes	0.320	102
Greeley	415	400	Chlorination	Shallow wells	0.03	75
Harveyville	204	200	Filtration, Chlorination	Impoundment	0.01	50
La Cygne	810	835	Chlorination	Wells	0.085	102
Lane	282	300	Chlorination	Shallow wells	0.015	50
Lebo	498	500	Filtration, Chlorination	Impounding Reservoir	0.03	60
Louisburg	862	900	Coagulation, Chlorination	Impoundment	0.06	67
Lyndon	953	975	Coagulation, Chlorination, Odor Control	Salt Creek	0.07	72
Melvern	376	400	Chlorination	Deep wells	0.02	50
Moran	549	600	Coagulation, Chlorination, Aeration	Impoundment	0.05	83

Exhibit No. 4 (Cont 'd)

Municipal Water Supplies

Osage River Basin Study (Kansas and Missouri)

Location	Population Served 1960	Population Served 1963	Water Treatment	Source of Supply	Average Plant Output MGD	Estimated GPCD
KANSAS (Cont'd)						
Mound City	661	685	Coagulation, Chlorination	L. Sugar Creek Impoundment	0.06	88
Mulberry	642	750	Aeration, Chlorination, Odor Removal	Deep well	0.05	67
Osage City	2,213	2,350	Coagulation, Chlorination, Aeration, Odor Control	Impoundment	0.15	64
Osawatomie	4,622	5,900	Fluoridation, Chlorination, Coagulation, Odor Control	Marais des Cygnes River and Impoundment	0.750	127
Ottawa	10,673	11,150	Fluoridation, Coagulation, Chlorination, Softening, Odor Control	Marais des Cygnes	1.00	90
Overbrook	509	500	Chlorination	Wells	0.03	60
Paola	4,784	4,750	Fluoridation, Softening, Chlorination	Bull Creek & Mida Lake	0.40	84
Parker	181	150	Chlorination, Filtration	Impounding Reservoir	0.01	67
Pleasanton	1,098	1,300	Coagulation, Chlorination	Muddy Creek Impoundment	0.138	106
Pomona	489	525	Chlorination	Deep wells	0.03	57
Quenemo	434	400	Chlorination	Wells	0.03	75
Richmond	352	375	Filtration, Chlorination	Impoundment	0.02	53
Scranton	576	550	Chlorination, Filtration	Impoundment	0.03	55
Spring Hill	909	875	Coagulation, Chlorination	L. Bull Creek Impoundment	0.07	80
Uniontown	211	200	Coagulation, Chlorination	Marmaton River & Impoundment	0.010	50
Waverly	381	450	Chlorination	Deep wells	0.035	78
Wellsville	984	1,065	Chlorination	Shallow wells	0.07	66
Williamsburg	255	260	Chlorination	Deep wells	0.01	38
MISSOURI						
Adrian	1,082	1,050	Coagulation, Chlorination, Aeration	Impoundment	0.17	162
Appleton City	1,075	950	Coagulation, Chlorination	Impoundment	0.072	76
Archie	348	380	Chlorination	Wells	0.091	240
Ash Grove	886	710	Chlorination	Wells	0.09	127

Exhibit No. 4 (2)

Exhibit No. 4 (Cont'd)

Municipal Water Supplies

Osage River Basin Study (Kansas and Missouri)

Location	Population Served 1960	Population Served 1963	Water Treatment	Source of Supply	Average Plant Output MGD	Estimated GPCD
MISSOURI (Cont'd)						
Billings	602	590	None	Well	0.03	51
Bolivar	3,512	3,508	None	Well	0.70	200
Buffalo	1,477	1,500	None	Wells	0.11	73
Butler	3,791	3,731	Coagulation, Chlorination	Miami River to Impoundment	0.438	117
Calhoun	374	300	Aeration, Chlorination	Wells	0.08	277
Camdenton	1,405	1,400	None	Wells	0.20	143
Chilhowee	339	440	Chlorination, Iron Removal	Well	0.022	50
Clinton	6,925	6,950	Coagulation, Chlorination	Grand River & Well	0.900	120
Conway	500	483	None	Well	0.0266	55
Crocker	821	768	None	Wells	0.096	125
Deepwater	712	703	Aeration, Chlorination	Well	0.05	71
Dixon	1,473	1,310	None	Wells	0.10	76
Eldorado Springs	2,864	2,580	None	Wells	0.225	87
Fairplay	335	311	None	Well	0.02	64
Garden City	600	550	Coagulation, Chlorination	Impoundment	0.015	27
Greenfield	1,172	1,048	None	Wells	0.10	95
Harrisonville	3,510	3,500	Aeration, Coagulation, Chlorination	Impoundments	0.25	71
Hermitage	328	312	None	Well	0.02	64
Humansville	745	725	None	Well	0.08	110
Hume	369	335	Chlorination, Iron Removal	Well	0.02	60
Iberia	694	640	None	Well	0.02	31
Lebanon	8,220	12,531	None	Well	1.00	80
Leeton	371	500	None	Well	0.02	40
Liberal	612	536	Aeration, Chlorination	Well	0.06	112
Lincoln	446	425	None	Well	0.045	106
Lockwood	835	769	None	Wells	0.065	85
Lowry City	437	398	None	Well	0.013	33
Marshfield	2,221	2,220	None	Wells	0.252	114
Montrose	526	496	Aeration, Chlorination	Wells	0.024	48

Exhibit No. 4 (3)

Exhibit No. 4 (Cont'd)

Municipal Water Supplies

Osage River Basin Study (Kansas and Missouri)

Location	Population Served 1960	Population Served 1963	Water Treatment	Source of Supply	Average Plant Output MGD	Estimated GPCD
MISSOURI (Cont'd)						
Nevada	8,416	8,500	Aeration, Chlorination	Wells	0.700	82
Osceola	1,066	915	Chlorination	Wells	0.07	77
Pleasant Hill	2,689	2,700	Aeration, Coagulation, Chlorination	Impoundment	0.25	93
Republic	1,519	1,650	None	Wells	0.065	39
Rich Hill	1,699	1,555	None	Wells	0.20	129
Richland	1,662	1,690	Fluoride Adjustment	Wells	0.09	53
Schell City	343	328	None	Well	0.01	30
Sheldon	434	450	None	Well	0.018	40
Springfield	95,865	98,365	Chlorination, Coagulation, Aeration, Fluoridation	Two Impoundments, aux. Fullbright, Spring and Wells	8.710	89
Stockton	838	840	None	Well	0.07	83
Urbana	348	350	None	Well	0.02	57
Vienna	536	484	None	Well	0.025	52
Walnut Grove	373	285	Chlorination	Well	0.05	175
Warsaw	1,054	920	None	Wells	0.075	82
Wheatland	305	300	None	Well	.014	40
Windsor	2,714	2,750	None	Wells	0.25	91
	225,286	233,801			21.521	92.0

Exhibit No. 4 (4)

Exhibit No. 5

Typical Chemical Analyses of Municipal Water Supplies
(Results in Milligrams per Liter)

Osage River Basin Study (Kansas and Missouri)

Location	Type*	Total Solids	Chloride (Cl^-)	Sulfate ($SO_4^=$)	Nitrate (NO_3)	Hardness (as $CaCO_3$)	Iron (Fe)	Remarks
KANSAS								
Arcadia	R	790	250	37	0.4	242	0.45	Frisco Well #2
Arma	T	651	232	71	0.4	108	0.01	Tap
	R	799	223	55	0.4	285	0.12	Deep Well
Baldwin	T	173	11	14	0.4	124	0.14	Ground Water
Burlingame	T	470	17	112	4.4	393	0.22	Surface Source
Edgerton	T	186	18	57	5.3	132	0.07	Surface Source
Eskridge	R	1,031	44	476	17.0	787	0.07	Well #3
Fort Scott	T	143	13	53	2.2	100	0.02	Surface Source
Gardner	T	181	14	33	3.1	146	0.08	Surface Source
Garnett	T	150	12	24	0.4	118	0.02	Surface Source
Louisburg	T	268	14	93	2.7	212	0.05	Surface Source
Lyndon	T	172	14	67	2.6	104	0.06	Surface Source
Moran	T	231	64	10	3.1	188	0.02	Surface Source
Mound City	T	293	13	49	0.4	266	0.02	Surface Source
Mulberry	R	565	150	36	2.0	226	0.01	Deep Well
Osage City	T	260	14	94	1.5	180	0.26	Surface Source
Osawatomie	T	269	22	83	2.2	198	0.01	Surface Source
Ottawa	T	173	21	50	3.2	108	0.05	Surface Source
Overbrook	R	576	152	21	0.4	159	1.6	East Well
Paola	T	107	13	21	1.9	56	0.06	Surface Source
Pleasanton	T	235	21	91	4.2	178	0.4	Surface Source
Pomona	T	328	35	6.6	0.4	234	0.36	Surface Source
Quenemo	R	589	36	102	62.0	426	0.01	S. Well
Richmond	T	196	8	19	1.5	160	0.12	Surface Source
Spring Hill	T	263	13	68	2.2	228	0.01	Surface Source
Waverly	T	450	14	66	1.5	20	0.03	Ground Water
Wellsville	T	153	8	14	1.9	104	0.56	Ground Water

Exhibit No. 5

Exhibit No. 5 (cont'd)

Typical Chemical Analyses of Municipal Water Supplies
(Results in Milligrams per Liter)
Osage River Basin Study (Kansas and Missouri)

Location	Type*	Total Solids	Chloride (Cl^-)	Sulfate ($SO_4^=$)	Nitrate (NO_3)	Hardness (as $CaCO_3$)	Iron (Fe)	Remarks
MISSOURI								
Adrian	T	292	11.4	107	-	156	0.06	Impoundment
Appleton City	T	251	12.7	97.9	-	140	0.05	Impoundment
Belton	R	543	30.4	98.3	2.5	295	0.4	Well
Bolivar	R	228	3.9	0	0.16	190	0.02	Well
Butler	T	371	17.7	121.8	-	216	0.04	Impoundment
Camdenton	R	317	4.5	1.6	0.27	264	0.02	Well
Clinton	T	264	10.9	77.4	-	154	0.06	Impoundment
Cole Camp	R	301	7.3	22.2	1.9	254	0.01	Well
Deepwater	R	2048	804	112	-	514	0.2	Well
Dixon	R	380	3.6	26.1	0.06	304	1.0	Well
Eldorado Springs	R	430	138.2	21.4	0	184	0.02	Well
Garden City	T	308	9.5	118.1	-	168		Impoundment
Harrisonville	T	241	9.5	59.5	-	168	0.04	Impoundment
Hermitage	T	315	4	26	-	252	0.14	Well
Ionia	R	285	3.9	27.2	0	262	0.4	Well
Knobnoster	R	363	26.8	36.8	0	252	0.25	Well
Leeton	R	444	70.8	33.9	0	214	1.4	Well
Liberal	R	490	112.3	22.4	0	190	0.14	Well
Linn Creek	R	346	3.9	7.4	0	318	0.03	Well
Lockwood	R	154	4.3	9.7	0	128	0.06	Well
Lowry City	R	370	16.4	74.7	0	176	0.07	Well
Marshfield	R	284	3.6	44.0	0	224	0.1	Well
Nevada	R	1,429	610.5	61.9	0.1	364	0.08	Well
Rich Hill	R	1,937	799	78.8	0	402	0.2	Well
Pleasant Hill	T	224	12.7	31.7	-	104	0.01	Impoundment
Richland	R	299	5.0	7.4	0	272	0.14	Well
Schell City	T	836	308	30	-	242	0.6	Well
Stockton	R	337	46.8	17.1	0	190	0.04	Well
Walnut Grove	R	195	5.2	10.5	0	160	0.25	Well
Warrensburg	R	511	109.4	30.8	0.12	256	0.3	Well

*R-Raw Water
T-Treated Water

Exhibit No. 6

Basic Data on Sources of Pollution

Osage River Basin Study (Kansas and Missouri)

Location	River Miles Above Mouth	Population 1960	Population Sewered	P.E. Before Tr.	Type of Waste	Treatment Provided	P.E. Discharged	Watercourse
KANSAS								
Baldwin City	390-10-15	1,877	1,870	1,870E	Domestic	Secondary	190E	Tavy Creek
Burlingame	424.7-30-4	1,151	1,000	1,000E	Domestic	Secondary	150	Switzler Creek
Edgerton	360.2-25	389	350	350	Domestic	Lagoon	40	Bull Creek
Fort Scott	273-18.2-23.2	9,410	9,300	13,300E	Dom. & Ind.	Tertiary	1,330	Marmaton River
Gardner	360.2-29	1,619	1,400	1,400E	Domestic	Secondary	210E	Dry Trib of Bull Creek
Garnett	367.4-31.2	3,034	3,000	4,400	Dom. & Ind.	Secondary	1,100	Trib. of Pottawatomie Ck
LaCygne	332.1	810	750	750	Domestic	Lagoons	75E	Marais des Cygnes
Lyndon	424.7-20.4	953	900	900E	Domestic	Secondary	135E	Salt Creek
Moran	273-18.2-65	549	400	400	Domestic	Secondary	80E	Dry Trib of Marmaton R.
Mound City	322-12	672	500	500E	Domestic	Lagoon	50	Little Sugar Creek
Osage City	424.7-20.4	2,213	2,100	2,700	Domestic	Secondary	540	Salt Creek
Osawatomie State Hospital	369.5		1,390	2,700	Domestic	Secondary	540	Marais des Cygnes
Osawatomie	367.4-1	4,622	4,600	4,600E	Domestic	Secondary	920	Pottawatomie Creek
Ottawa	399	10,673	10,500	14,000E	Dom. & Ind.	Secondary	2,100	Marais des Cygnes
Overbrook	420-20	569	500	500E	Domestic	Lagoons	75E	Trib of 110 Mile Creek
Paola	360.2-8.6	4,784	4,600	6,600	Dom. & Ind.	Secondary	1,800E	Bull Creek
Pleasanton	305-15	1,098	750	750	Domestic	Lagoons	115E	Cady's Creek
Quenemo	427.7	434	400	350	Domestic	Lagoons	50	Marais des Cygnes
Spring Hill	360.2-16	882	600	600	Domestic	Lagoon	60	Bull Creek
Wellsville	390-6-11	984	1,000	1,000E	Domestic	Secondary	150	Walnut Creek
MISSOURI								
Adrian	175.6-80-12	1,082	1,000	1,000E	Domestic	Lagoons	100E	Br of West Deer Creek
Appleton City	245-20	1,075	500E	500E	Domestic	Lagoon	50E	Br of Monegan Creek
Ash Grove	235.3-62-15	886	870	870E	Domestic	Secondary	90E	Br of Pickeral Creek
Belton	175.6-125	4,897	4,800	4,800	Domestic	Secondary	480	Br of East Creek
Bolivar	187.2-65-3	3,512	3,100	4,300	Dom. & Ind.	Secondary	900	Town Branch

Exhibit No. 6

Exhibit No. 6 (Cont'd)

Basic Data on Sources of Pollution

Osage River Basin Study (Kansas and Missouri)

Location	River Mile Above Mouth	Population 1960	Population Sewered	P.E. Before Tr.	Type of Waste	Treatment Provided	P.E. Discharged	Water Course
MISSOURI (Con'd)								
Buffalo	187.2-40-38	1,477	1,220	1,700E	Dom. & Ind.	Secondary	250E	Br. of Lindley Creek
Butler	282-8-5	3,791	3,250	3,500E	Dom. & Ind.	Lagoon	350E	Mound Root Creek
Camdenton	112.8-5	1,405	600	600	Domestic	Lagoon	60E	Niangua River
Camdenton	108-5		600	600	Domestic	Lagoon	60E	Br. of Linn Creek
Clinton	175.6-40	6,925	4,200	4,200E	Domestic	Lagoon	420E	Grand River
Clinton	175.6-37-3		2,000	2,000E	Domestic	Lagoon	200E	Coal Ck. to Grand R.
Cole Camp	171-22	853	680	680	Domestic	Secondary	68	Cole Camp Creek
Crocker	50-50	821	400	400E	Domestic	Secondary	40E	Br. of Tavern Creek
Deepwater	175.6-32-3	712	600	600E	Domestic	Secondary	60E	Ratt Creek
Dixon	9.9-60	1,473	1,300	1,300E	Domestic	Secondary	150E	Maries Creek
Drexel	175.6-87-25	651	640	640	Domestic	Lagoons	64	Branch to Marais des Cygnes
Eldorado Springs	253.9-15-3	2,864	2,600	8,200E	Domestic	Secondary	700E	Walnut Creek
Greenfield #1	235.3-77-7-2.5	1,172	1,000	1,000E	Domestic	Lagoons	100E	Wilson Branch
Greenfield #2	235.3-64-9-4		100	2,100E	Dom. & Ind.	Lagoons	210E	Whetzel Branch
Greenfield #3	235.3-64-9-3-1		150	150E	Domestic	Lagoon	15E	Whetzel Branch
Harrisonville	175.6-95-15	3,510	3,460	3,460	Domestic	Secondary	346E	Branch of East Branch of Grand R.
Humansville	235.3-20-15	745	700	700E	Domestic	Lagoon	70E	Brush Ck. to Sac River
Lebanon	100.5-5-45	8,220	7,400E	10,700E	Dom. & Ind.	Secondary	1,070E	Dry Auglaize Creek
Liberal	273-18.2-18-23	612	23	123	Domestic	Lagoon	No Discharge	Dry Wood Creek
Lincoln	179-11-2	446	420E	420	Domestic	Lagoon	42E	Br. of Little Tebo River to Tebo River to Lake of Ozarks
Lockwood	235.3-25-50	835	835	835E	Domestic	Secondary	135E	Horse Ck to Sac R.
Marshfield	112.8-110	2,221	2,000	2,000E	Domestic	Lagoon	200E	Br. of Niangus River
Nevada	273-11-15-3.2	8,416	7,800	7,800E	Domestic	Secondary	1,100E	Marmaton River
Nevada State Hospital	273-11-15-3.2			2,700	Domestic	Secondary	400	Marmaton River

Exhibit No. 6 (2)

Exhibit No. 6 (Con t 'd)

Basic Data on Sources of Pollution

Osage River Basin Study (Kansas and Missouri)

Location	River Miles Above Mouth	Population 1960	Population Sewered	P.E. Before Tr.	Type of Waste	Treatment Provided	P.E. Discharged	Watercourse
MISSOURI (Con'd)								
Osceola	230.9	1,066	460	460E	Domestic	Primary	375E	Osage River
Pleasant Hill	175.6-53-60	2,689	2,100	2,100E	Domestic	Lagoon	210E	Big Creek
Republic	235.3-92-2-2	1,519	1,450	1,450E	Domestic	Secondary	150E	Br. of Pickeral Creek
Rich Hill	278-5	1,699	300	300E	Domestic		200E	Park Branch and Muddy Creek
Richland	116-8.5-9-7	1,662	1,600	1,600	Domestic	Lagoon	160	Coons Creek
Sheldon	253.9-52	434	400	1,000E	Dom. & Ind.	Lagoon	110E	Clear Creek
Springfield NW	235.3-45-55		23,000	23,000E	Domestic	Secondary	2,300E	Dry Sac Fork to Little Sac River
Stockton	235.3-38-2.5	838	750	750E	Domestic	Lagoons	75E	Stockton Branch
Warsaw	173.5	1,054	680E	680E	Dom & Ind.	Lagoon	80E	Lake of the Ozarks
Windsor	175-13-8-11	2,714	2,600	3,400E	Dom & Ind.	Secondary	500E	Branch of East Tebo Creek
	Totals	118,939	131,498	161,288			21,600	

Exhibit No. 6 (3)

Exhibit No. 7

Summary of Most Feasible Alternatives for Municipal and Industrial Water Supplies
Osage River Study Area

Alternative	Construction Cost $	Year of First Need	Annual* Cost $	Annual Operating and Maintenance Cost $	1960 Worth** of Annual Cost $
Single Purpose Reservoir Subarea 4 (Ottawa Area)	2,150,000	1980	77,500	15,000	50,000
Single Purpose Reservoir Subarea 5 (Garnett Area)	700,000	2010	25,200	8,000	7,100
Single Purpose Reservoir Subarea 6 (Paola Area)	2,800,000	1960	101,000	20,000	121,000
Pumping System	280,000	1960	10,100	2,500	12,600
Subarea 7 (Butler Area)	280,000	2010	10,100	16,600	5,700
Subarea 7 - Annual value of storage for municipal and industrial water supply					18,300
Single Purpose Reservoir Subarea 8 (Fort Scott and Nevada Areas)	2,000,000	2010	72,100	15,000	18,700
Single Purpose Reservoir Subarea 12 (Harrisonville Area)	1,000,000	1990	36,100	8,000	17,500
Single Purpose Reservoir Subarea 12 (Freeman Area)	7,600,000	1980	274,000	25,000	161,600

* Amortized 25 years @ 4%, capitalized 25 years @ 3 1/8%, and amortized 100 years @ 3 1/8%

** Discounted @ 3 1/8%

Exhibit No. 8

Summary of Most Feasible Alternates for Water Quality Control
Osage River Study Area

Location	Alternative	Construction Cost $	Year of First Need	Annual* Cost $	Annual Operating and Maintenance Cost $	1960 Worth of Annual Cost $
Subarea 4 (Ottawa and Osawatomie Areas)	Single Purpose Reservoir	2,200,000	1960	72,100	10,000	82,100
Subarea 5 (Garnett Area)	Holding Pond	89,400	2040	3,000	3,000	500
Subarea 6 (Paola Area)	Single Purpose Reservoir	2,600,000	1960	85,200	10,000	92,200
Subarea 7 (Butler Area)	Single Purpose Reservoir	1,400,000	1960	46,000	10,000	56,000
Subarea 8 (Ft. Scott and Nevada Areas)	Single Purpose Reservoir	2,000,000	1960	66,000	10,000	76,000
Subarea 9 (Eldorado Springs Area)	Single Purpose Reservoir	1,600,000	1960	53,000	10,000	63,000
Subarea 12 (Harrisonville Area)	Single Purpose Reservoir	1,150,000	1960	38,000	8,000	46,000

* Amortized 100 years @ 3 1/8%

Exhibit No. 8

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